Development and applications of Time Correlated Single Photon Counting at ALBA

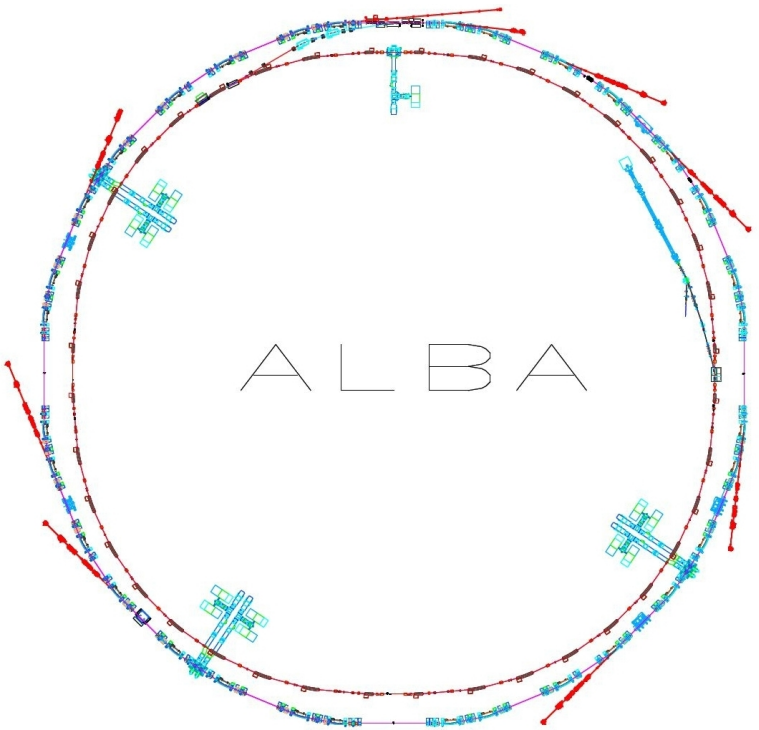
Laura Torino

October 8, 2015
Seville, Spain
International Conference on Accelerator Optimization

ALBA

The Facility

- Energy: 3 GeV
- Current: up to 400 mA
- RF-Frequency 500 MHz
- Seven active beamlines
  - +1 Optical beamline
  - +1 x-ray Fronted



Beam Diagnostic using SR

SR characteristics
⇕
Beam characteristics

Advantages

- Produced "for free"
- Wide spectrum
- Real-time
- Non-destructive

Disadvantages

- Need of a source
- Radiation exposure
- "Localized"
- Machine design

Beam Diagnostic using SR

SR characteristics
⇕
Beam characteristics

Advantages

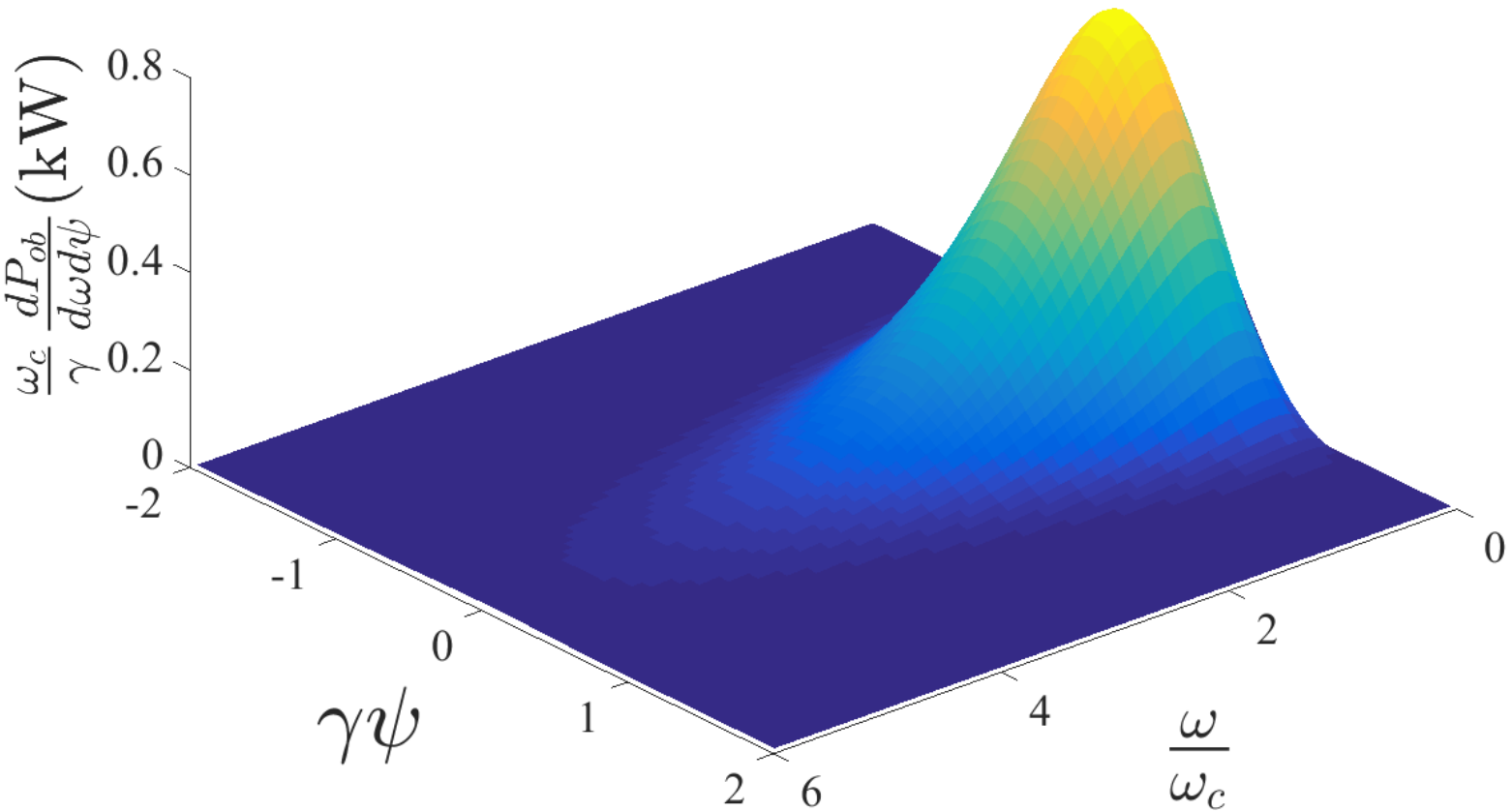
- Produced "for free"
- Wide spectrum
- Real-time
- Non-destructive

Disadvantages

- Need of a source
- Radiation exposure
- "Localized"
- Machine design

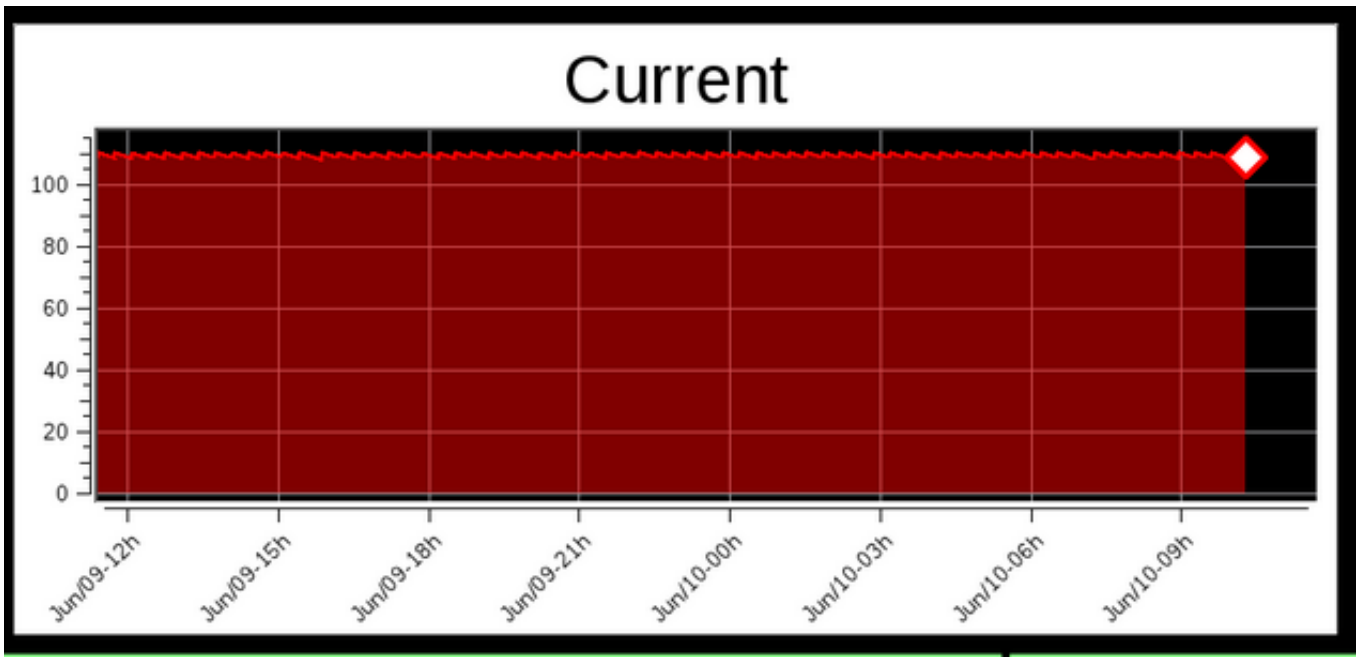
Longitudinal and transverse beam characteristics can be inferred from the synchrotron radiation

Power Distribution

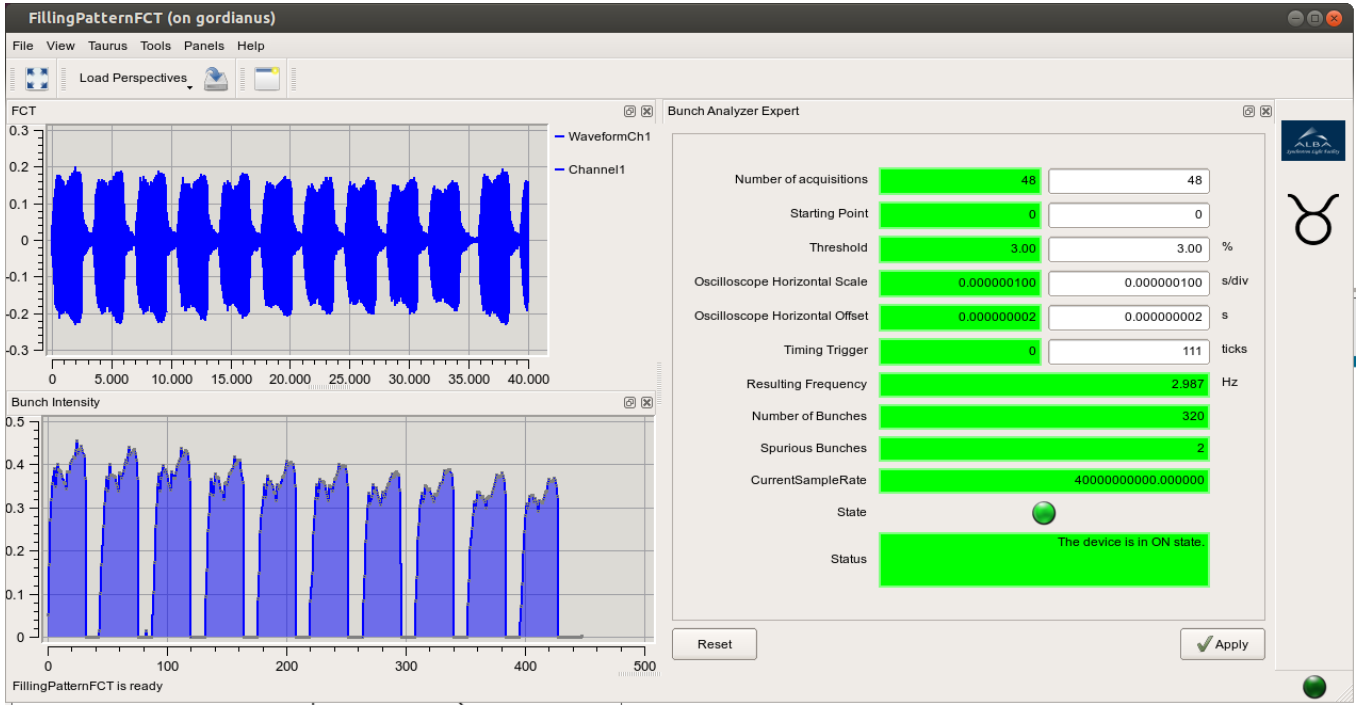


Motivation

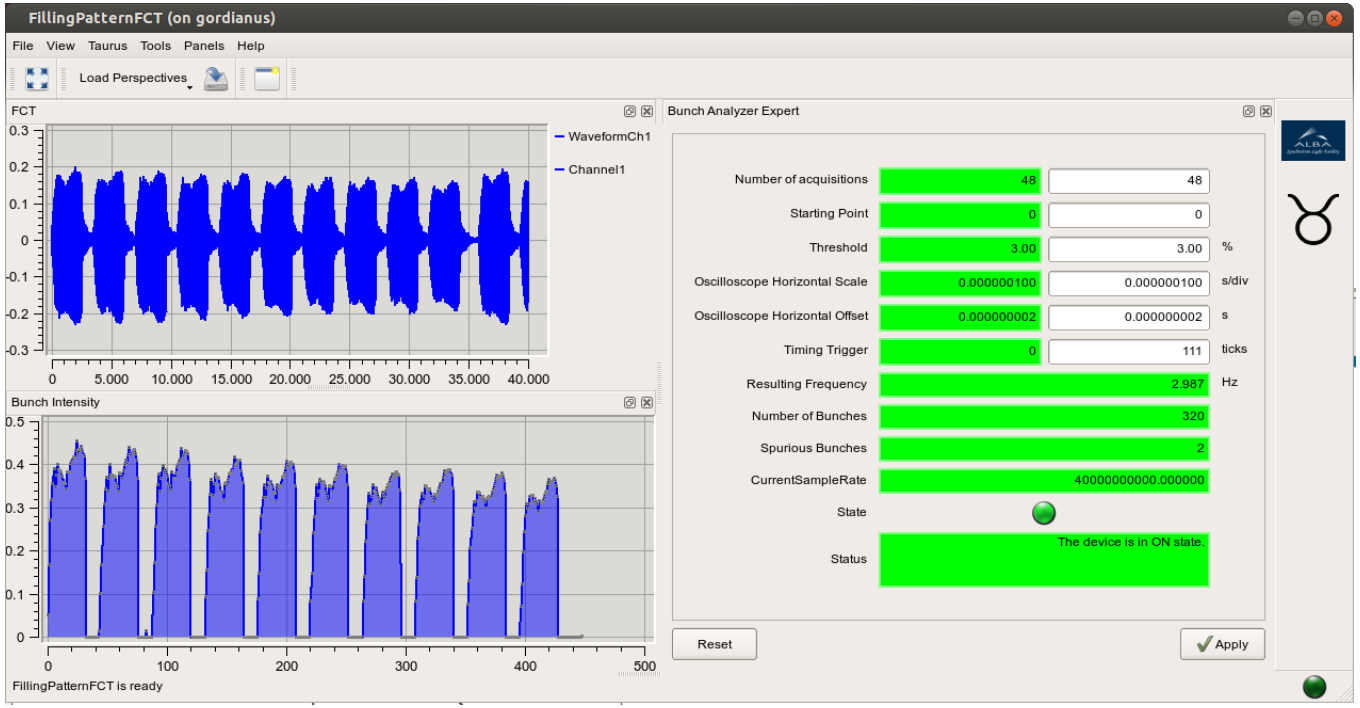
Filling pattern measurements are needed for selective top-up operation.
Future bunch purity measurements will be needed for time resolved experiments.



Fast Current Transformer

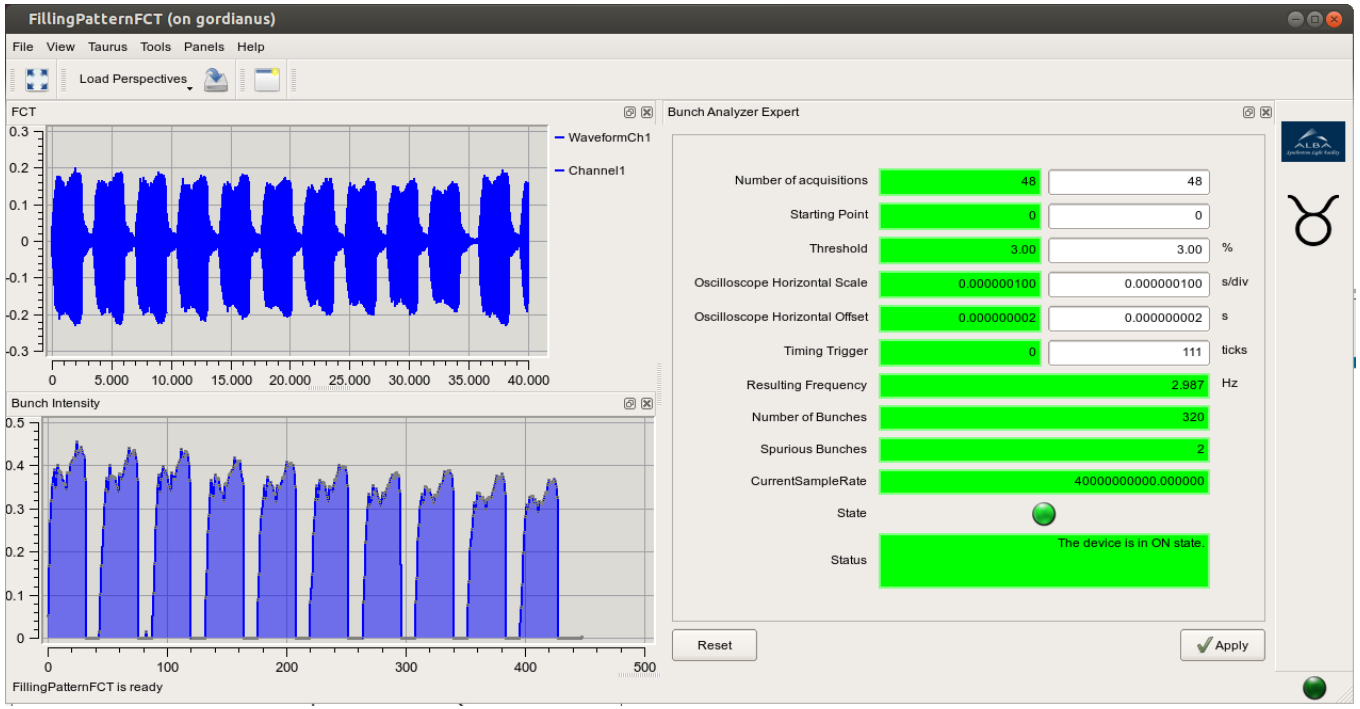


Fast Current Transformer



- Reliable
- Online
- Fast

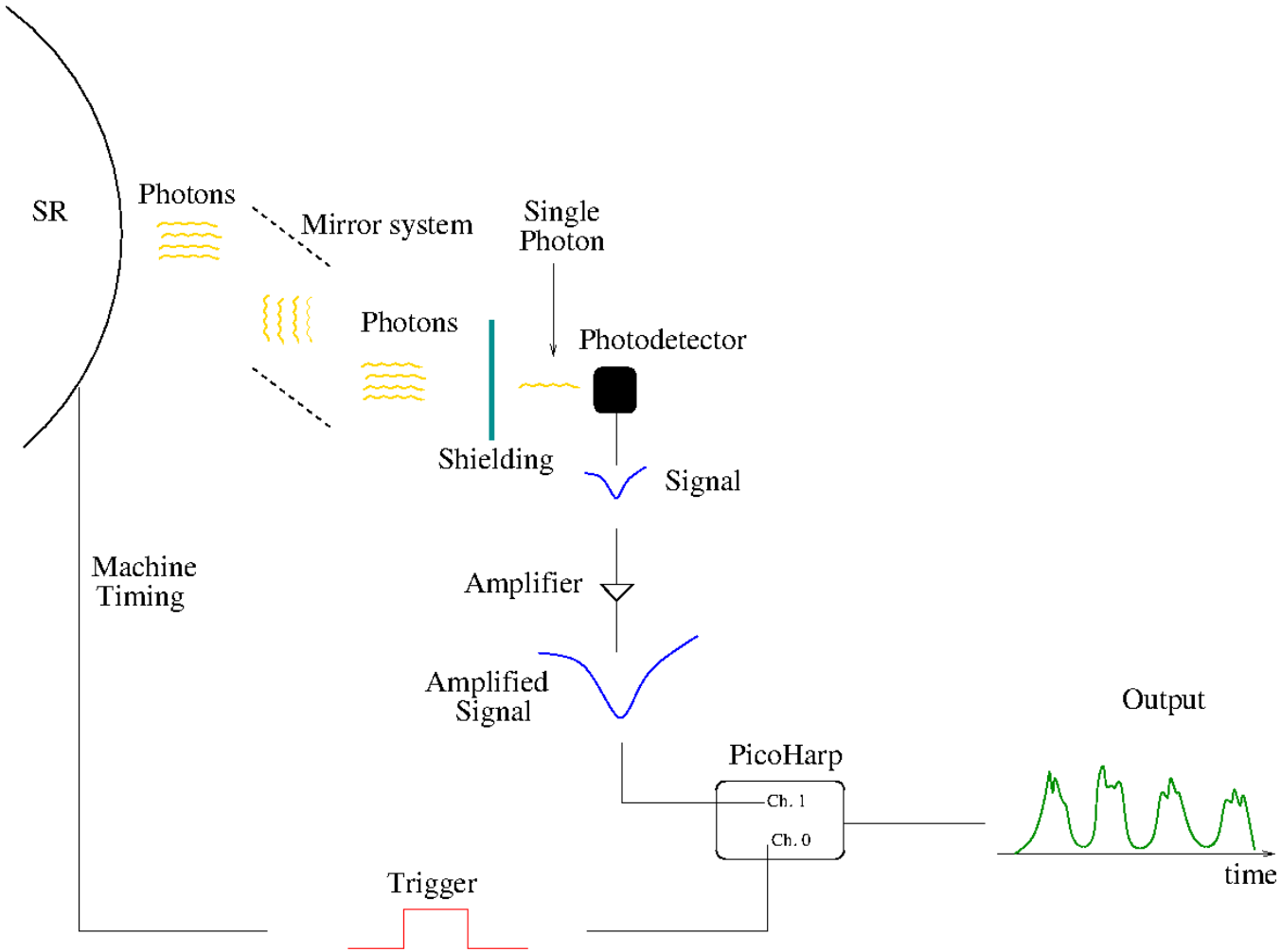
Fast Current Transformer



- Reliable
- Online
- Fast

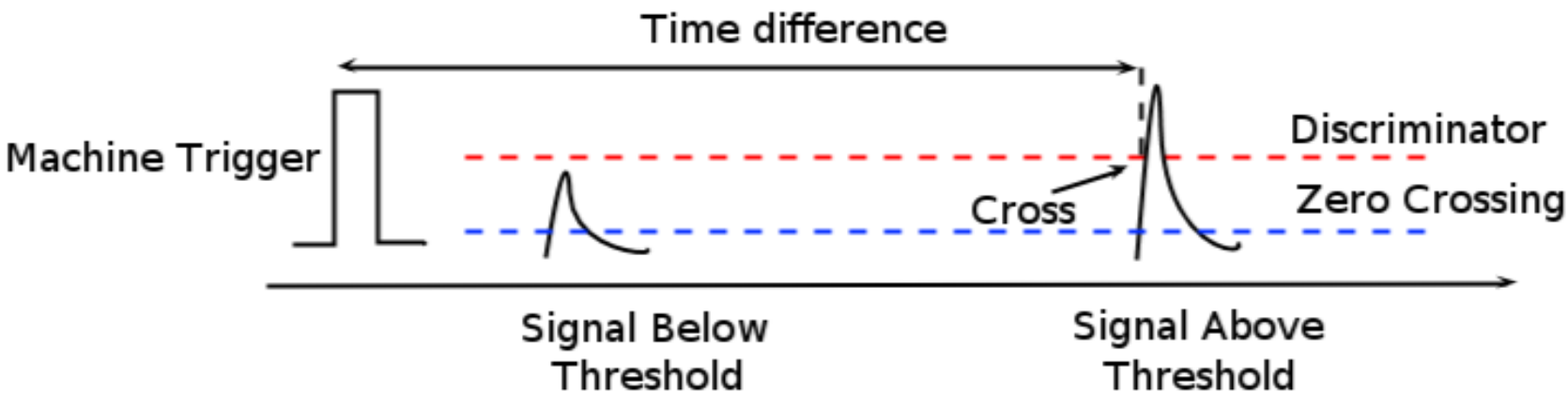
- Shared oscilloscope
- Dynamic range $< 10^2$
- Only way of measurement

TIME CORRELATED SINGLE PHOTON COUNTING



Photon Counter

PicoHarp300	
Input voltage range	0 to -800 mV
Bin width	4-8...512 ps
Maximum sync rate	84 MHz
Dead time	< 95 ns



Photon Detector

PMT Hamamatsu H10721-210	
Photocathode Material	Ultra Bialkali
Spectral Response	230-700 nm
Input Voltage	4.5-5.5 V
Max. Input Current	2.7 mA
Max Output Signal Current	100 μ A
Control Voltage Range	$0.5 - 1.1$ V
Gain (Control Voltage: 1 V)	10^6
Dark Current	10 nA
Rise Time	0.57 ns
Ripple Noise (peak to peak)	0.3 mV

Photon Detector Characterization

Instrumental Response Function

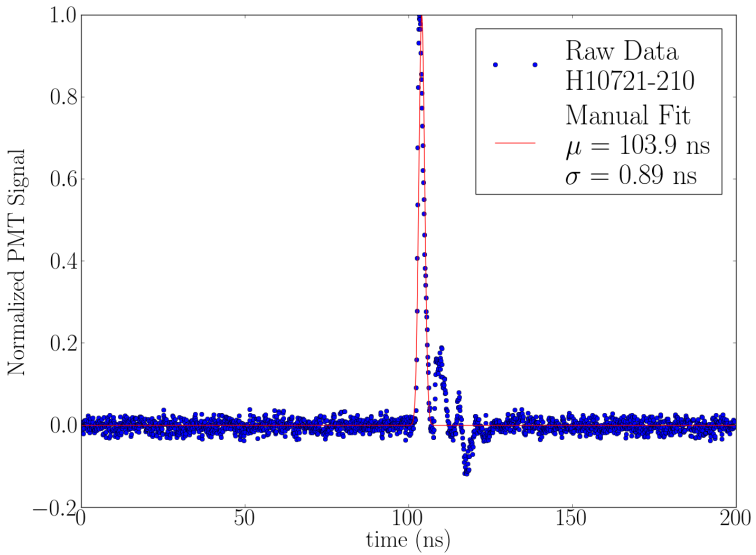


Image from the oscilloscope

σ of the output signal of the device when detecting an isolated photon

0.89 ns

Transit Time Spread

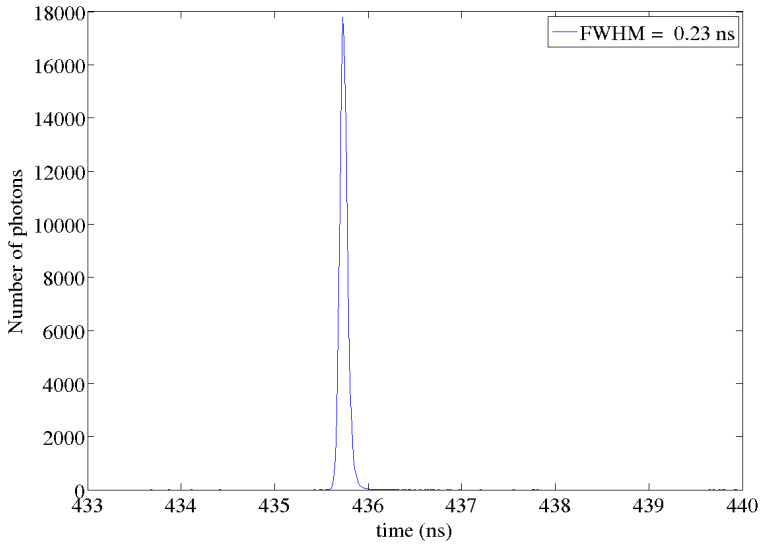


Image from the Picoharp

FWHM of electron transit time fluctuation between the photocathode and the signal

0.23 ns

Photon Detector Characterization

Instrumental Response Function

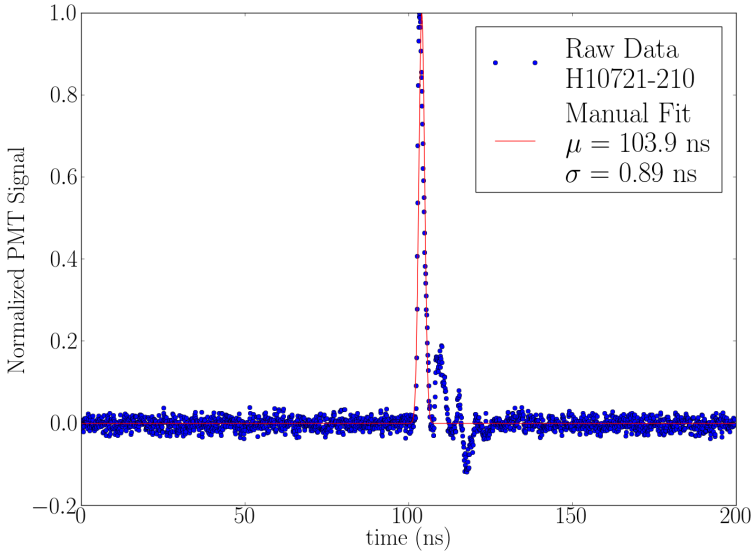


Image from the oscilloscope

σ of the output signal of the device when detecting an isolated photon

0.89 ns

Transit Time Spread

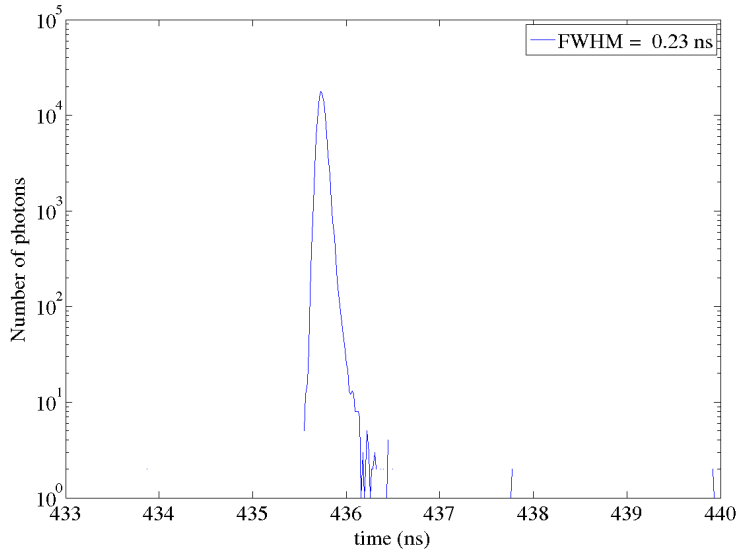
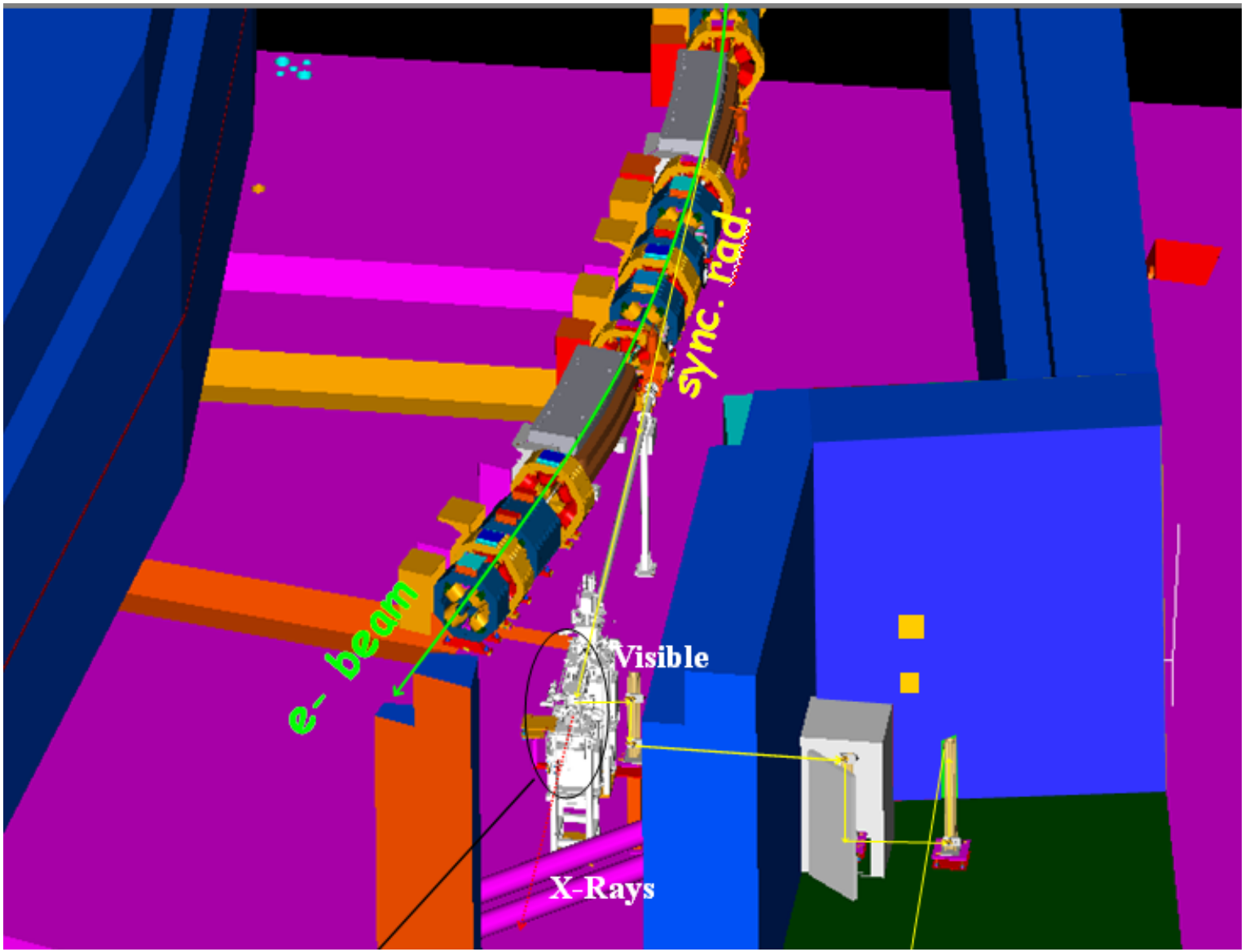


Image from the Picoharp

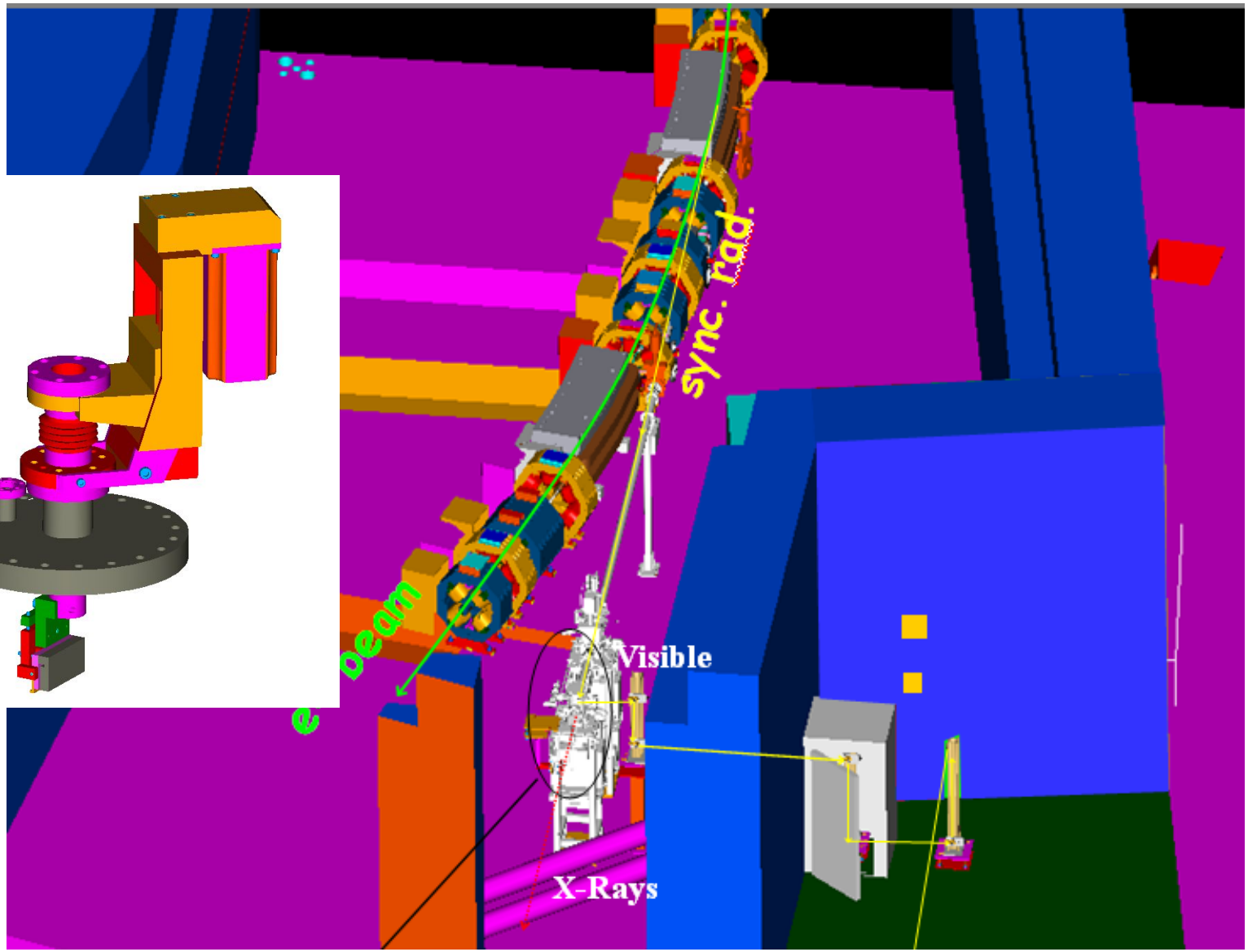
FWHM of electron transit time fluctuation between the photocathode and the signal

0.23 ns

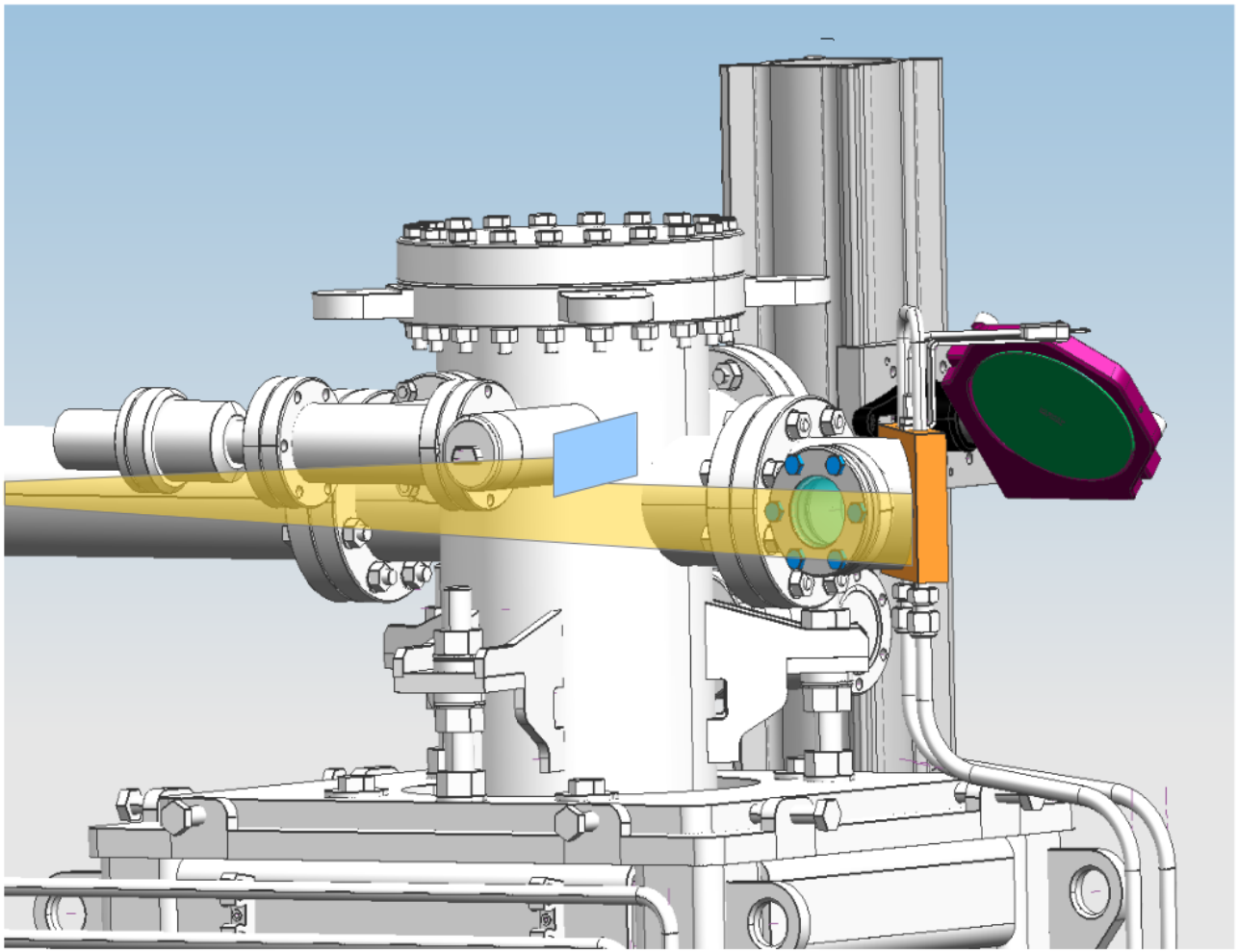
Diagnostic Beamline



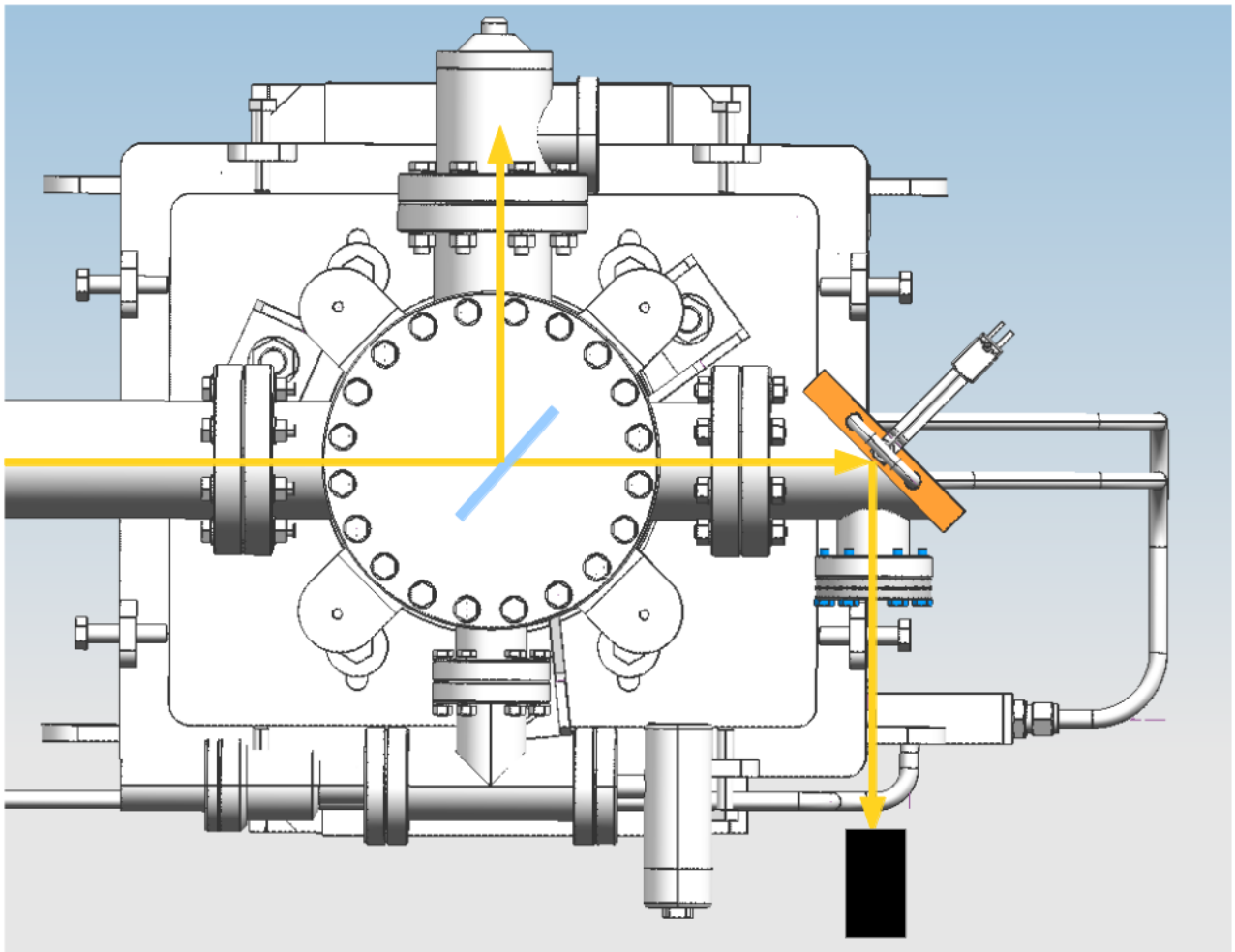
Diagnostic Beamline



FRONTEND



FRONTEND

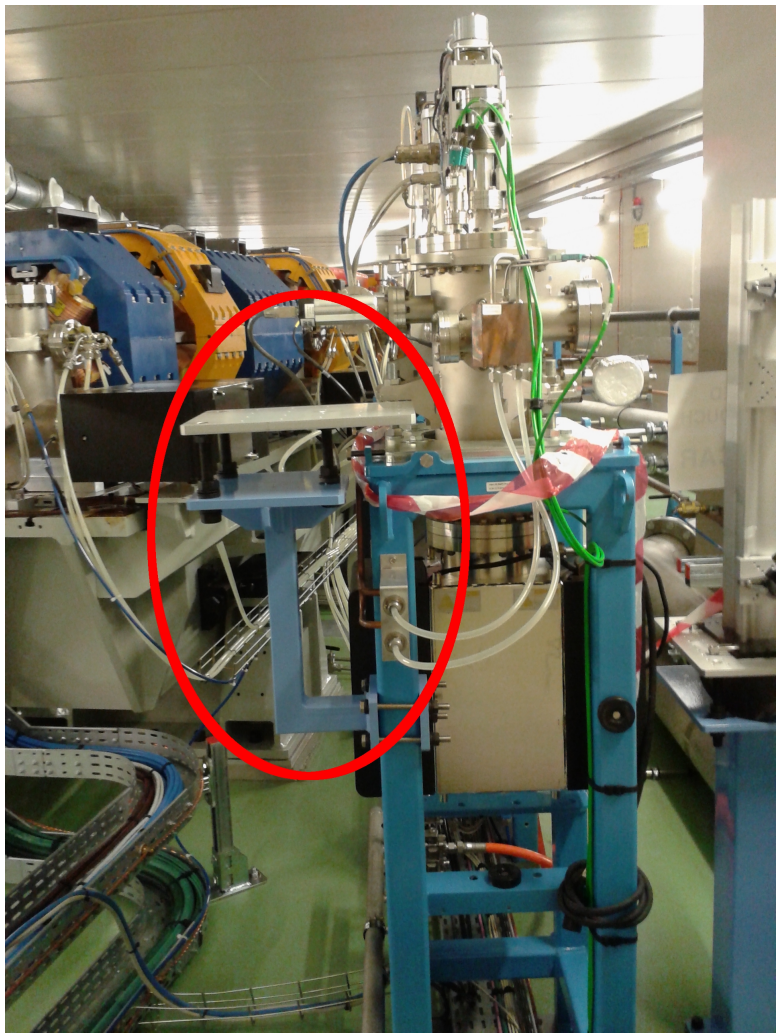


Real Frontend

Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on

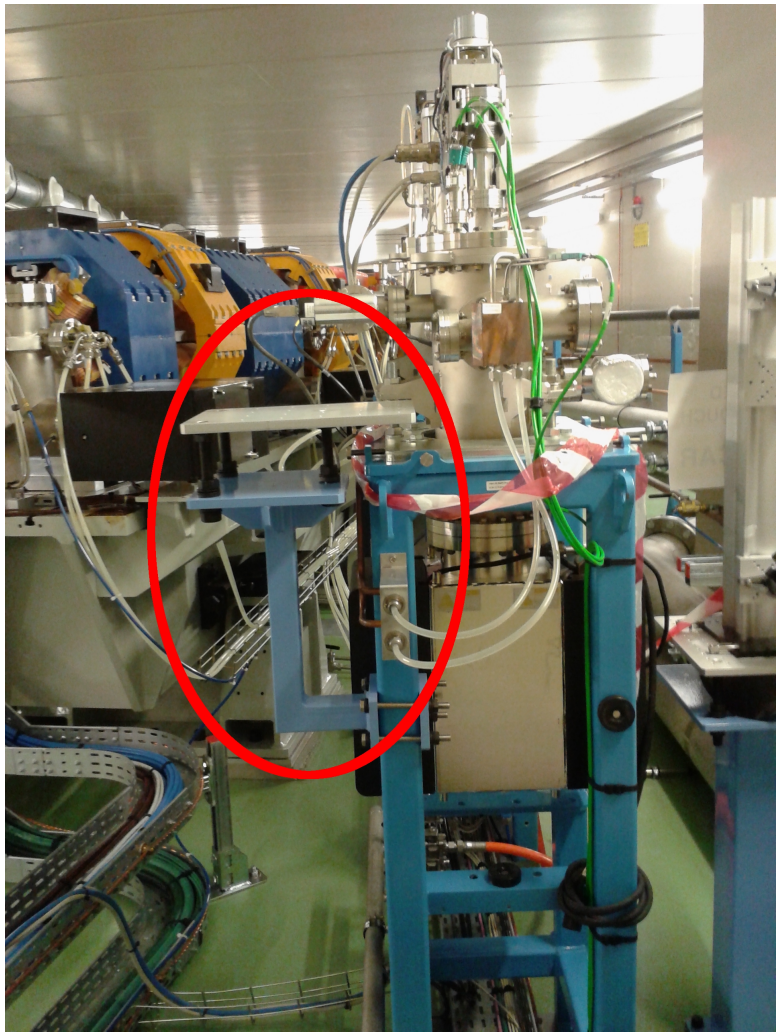
Real Frontend



Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on

Real Frontend

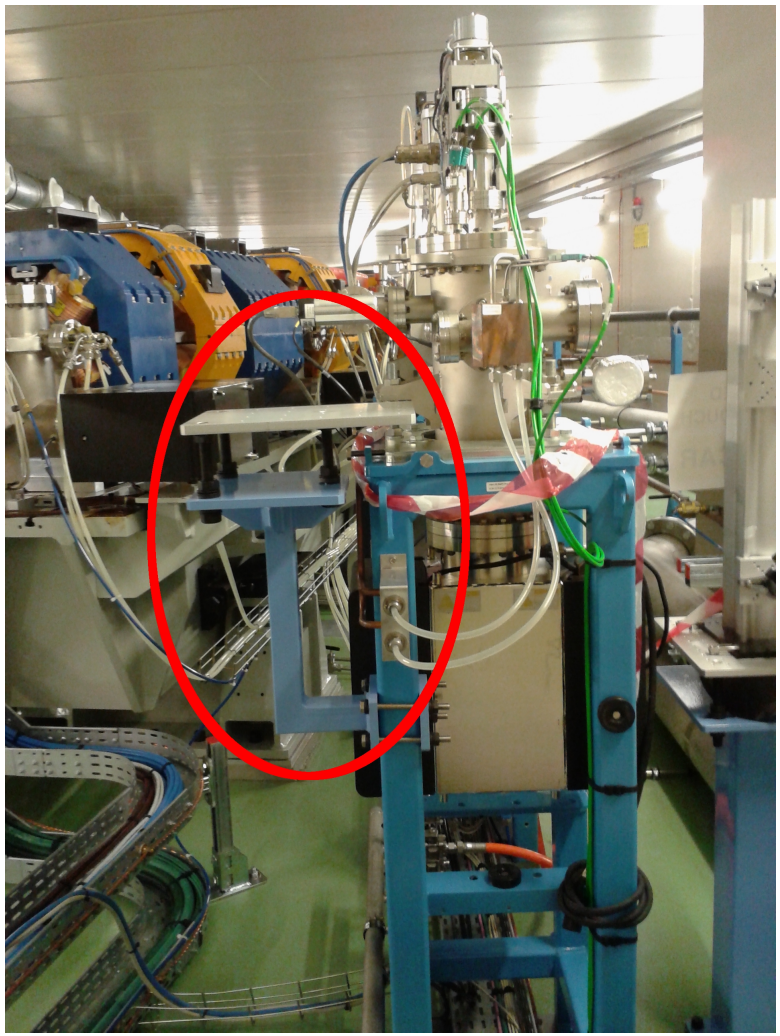


Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on

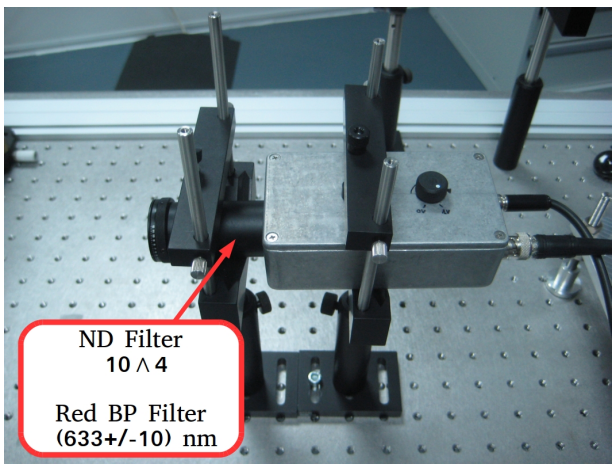
Cabling everything outside the tunnel

Real Frontend

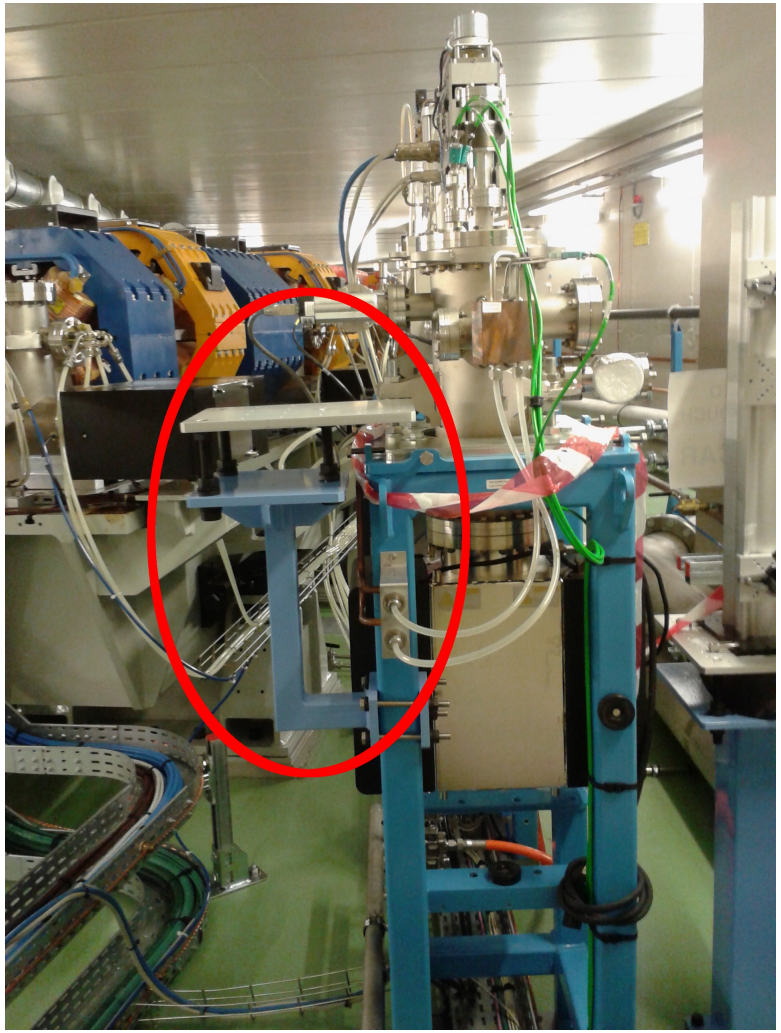


Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on

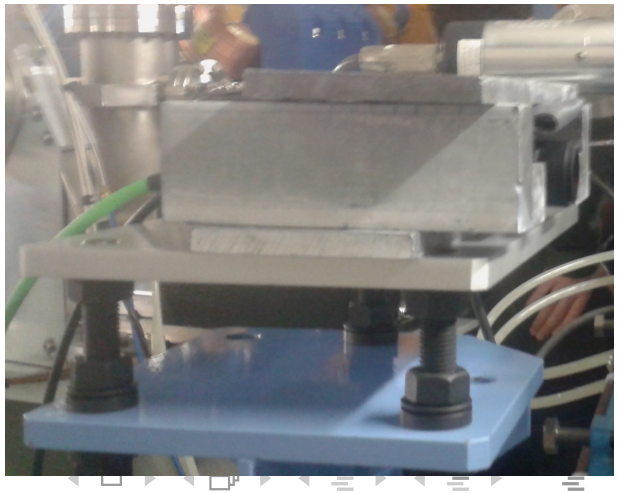


Real Frontend

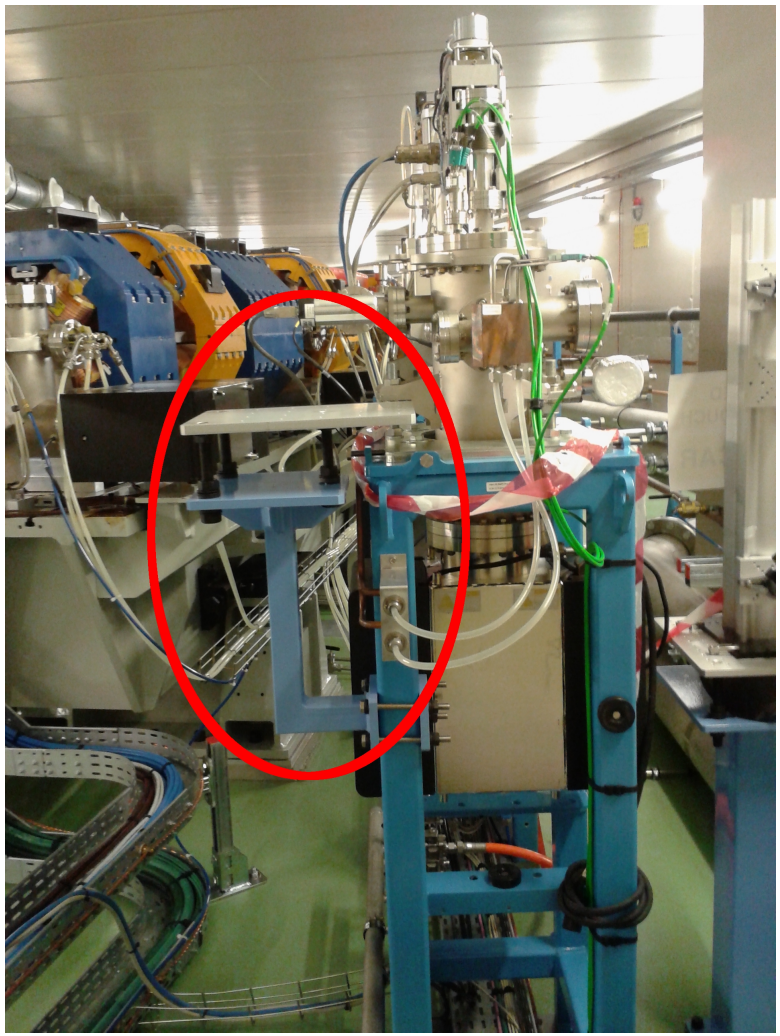


Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on



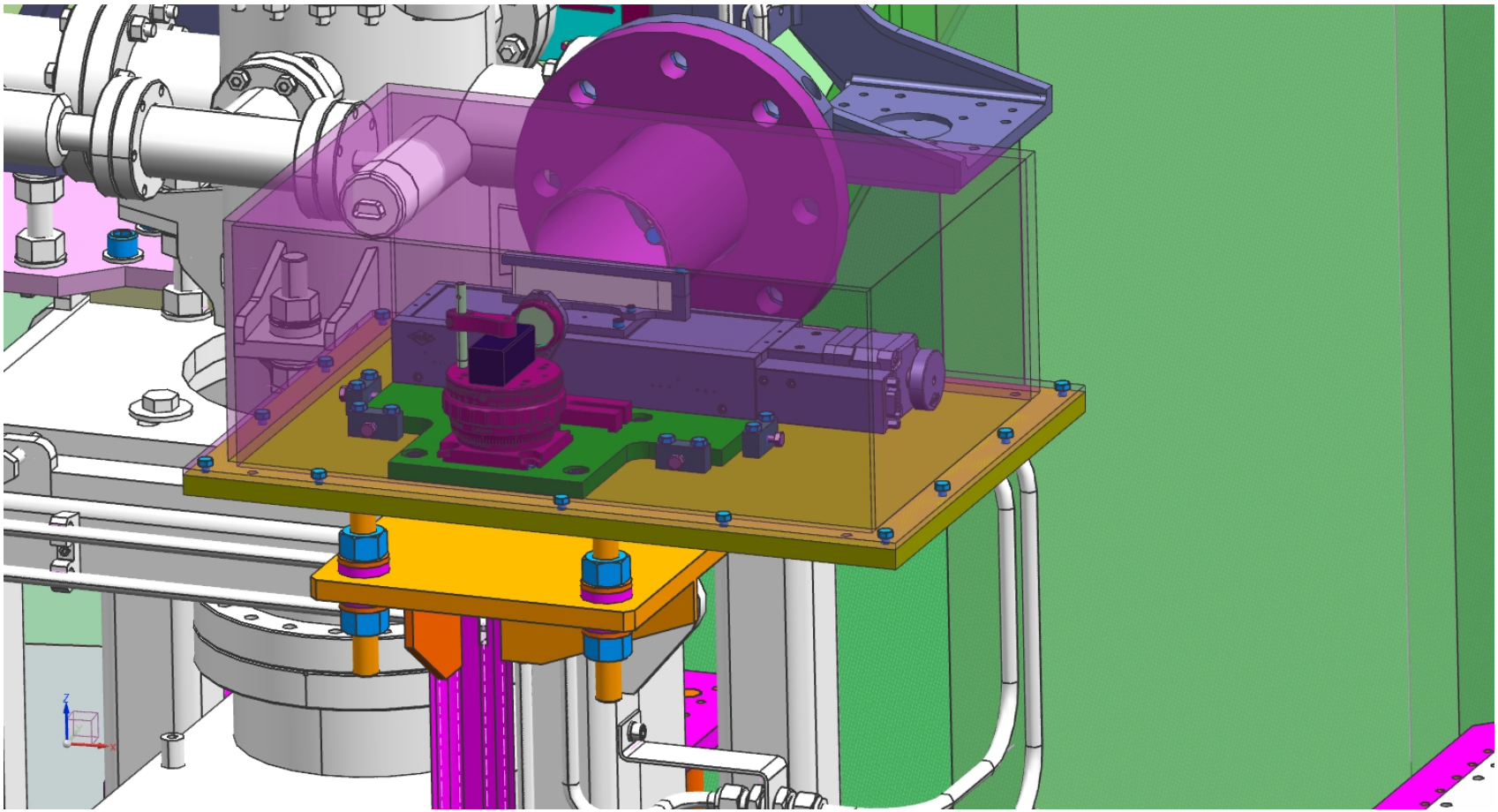
Real Frontend



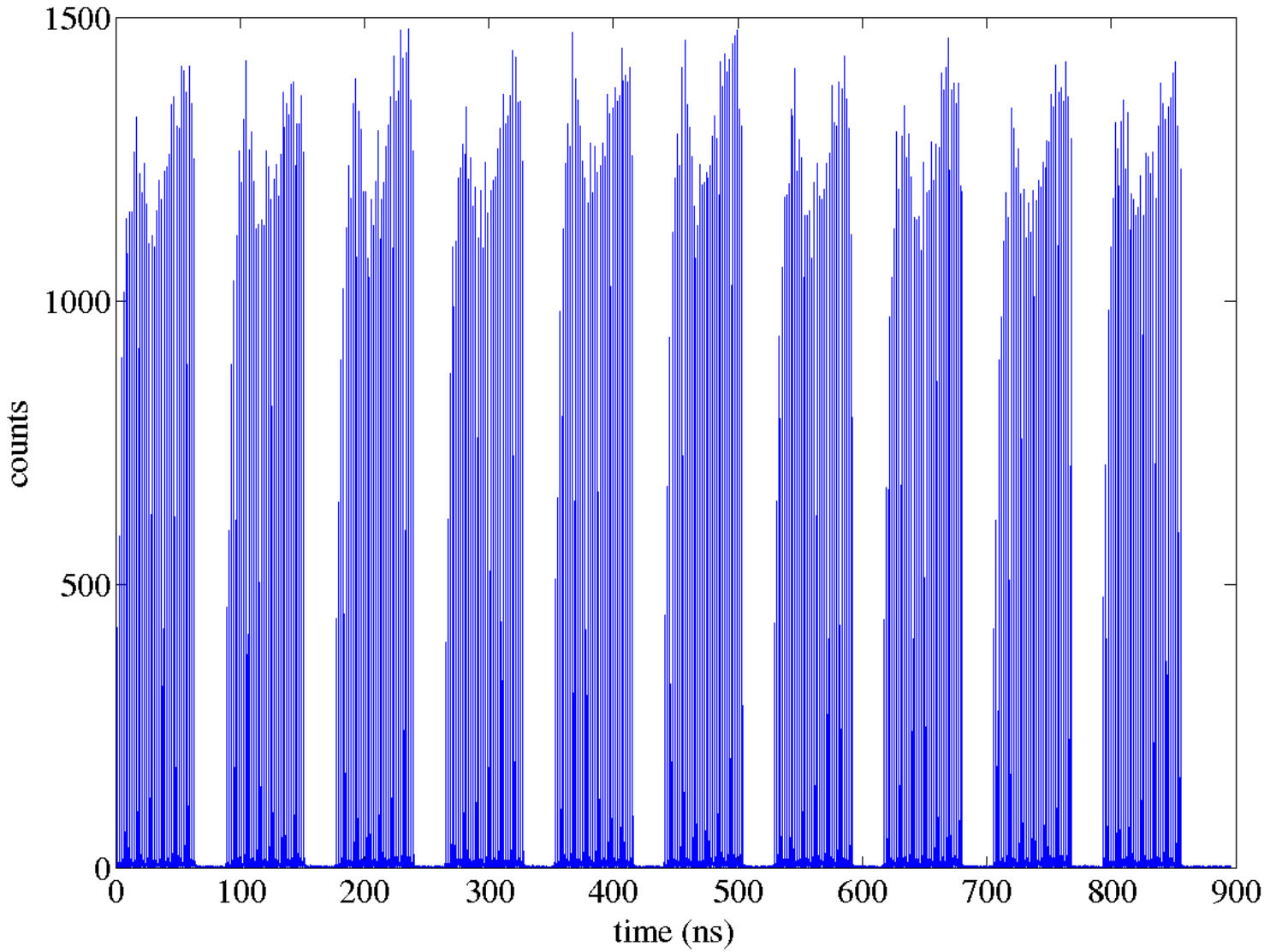
Problems

- Support
- Remote control
- Single Photon
- Radiation
- Light always on

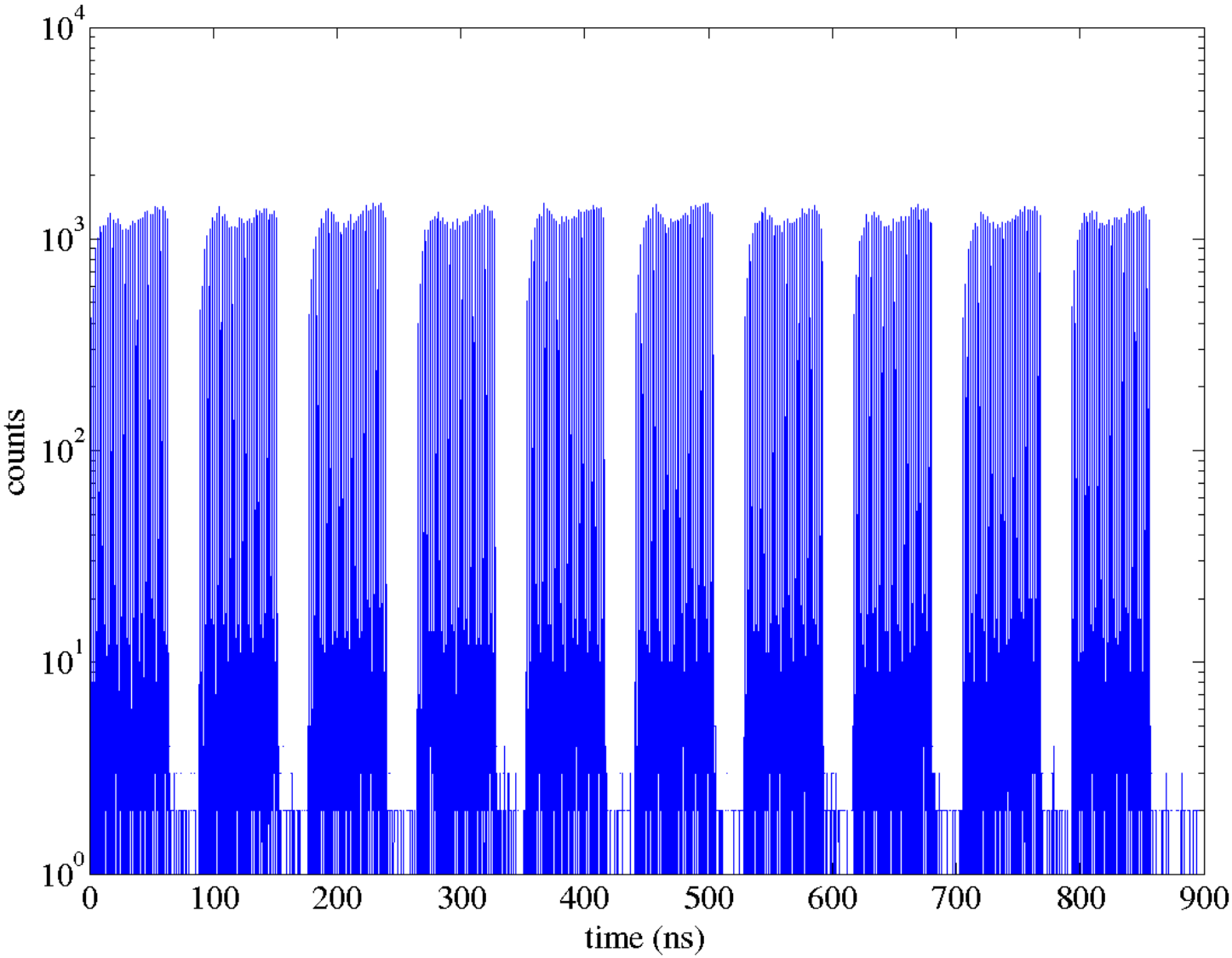
FUTURE



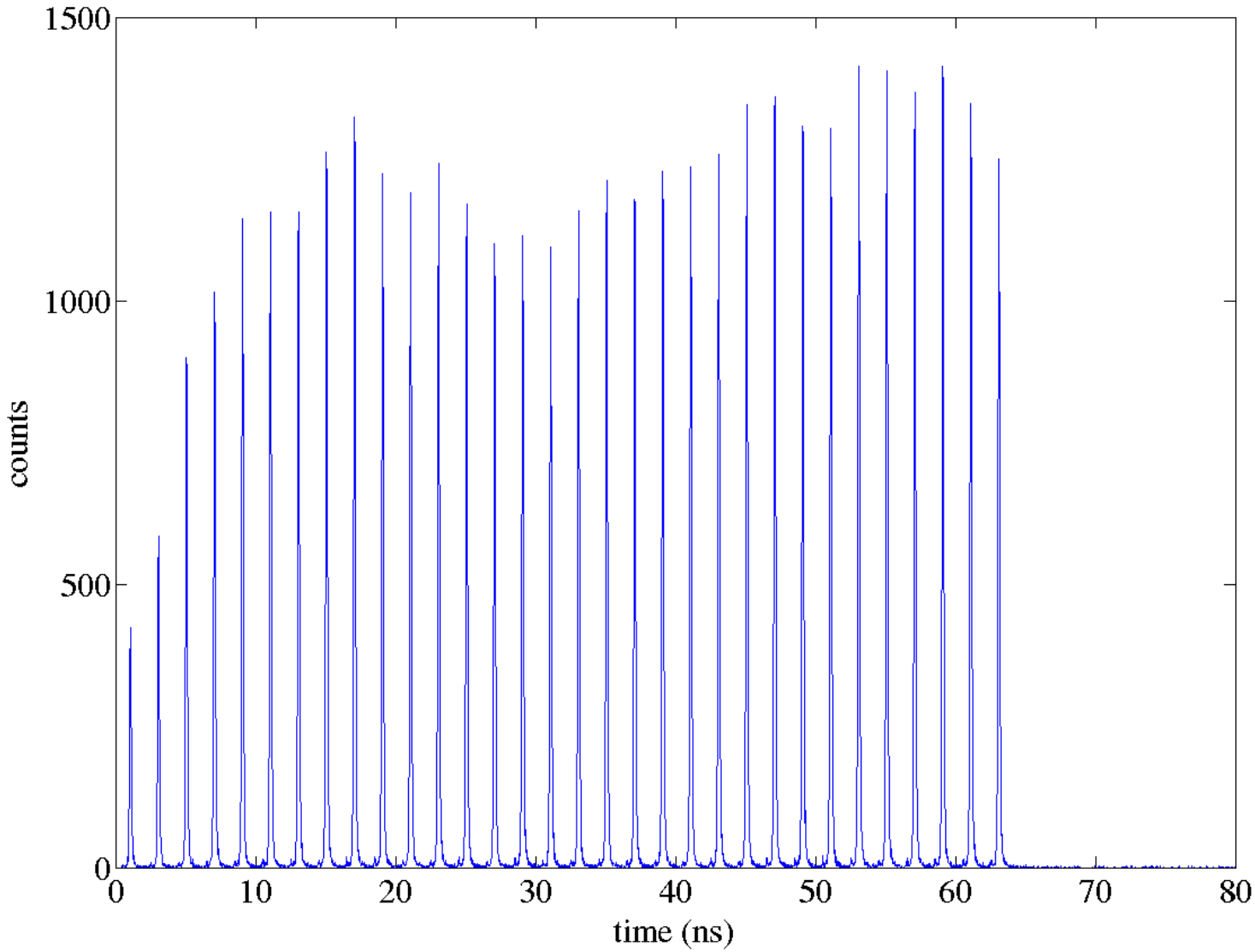
Operation Filling Pattern



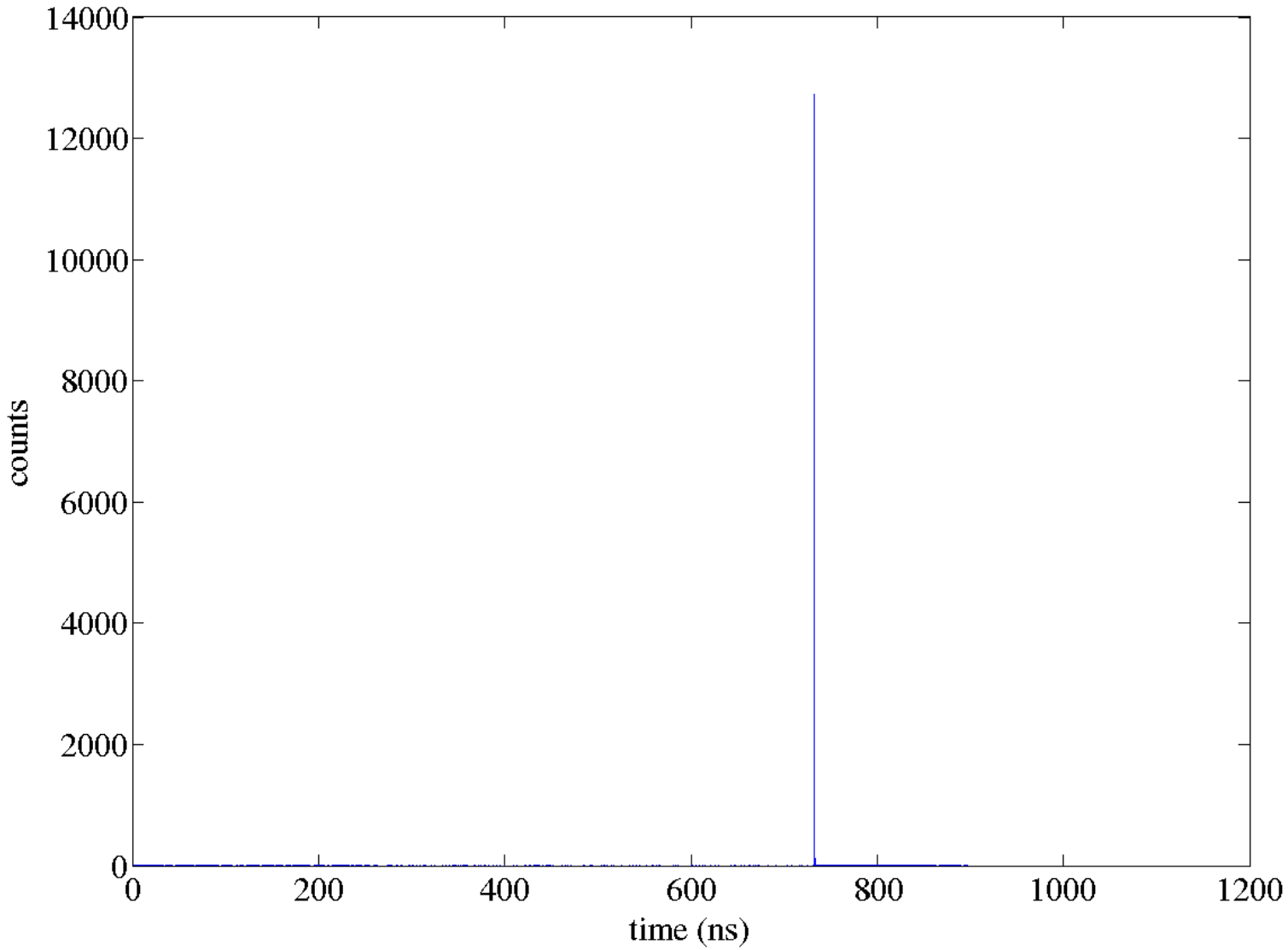
Operation Filling Pattern



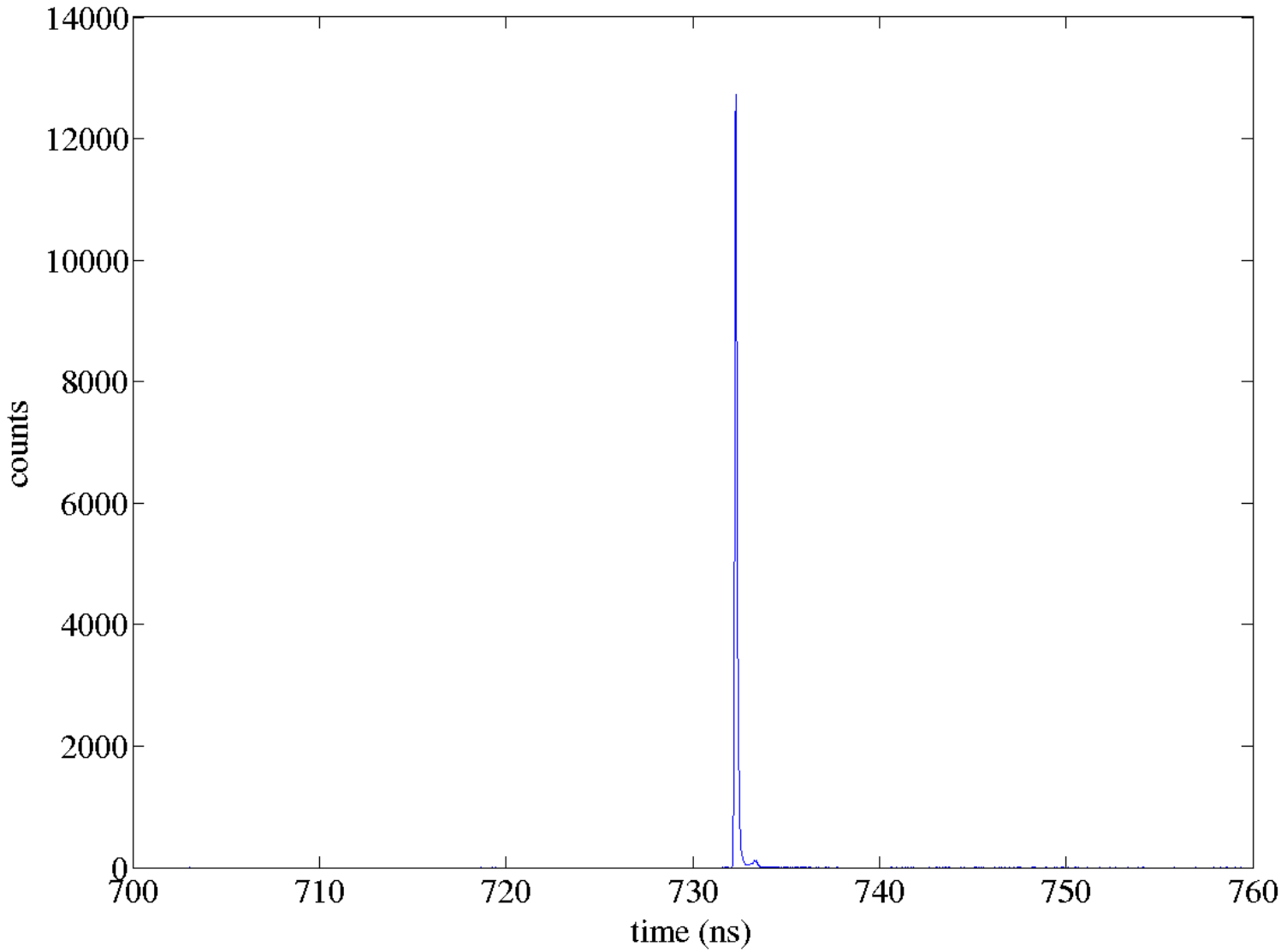
Operation Filling Pattern



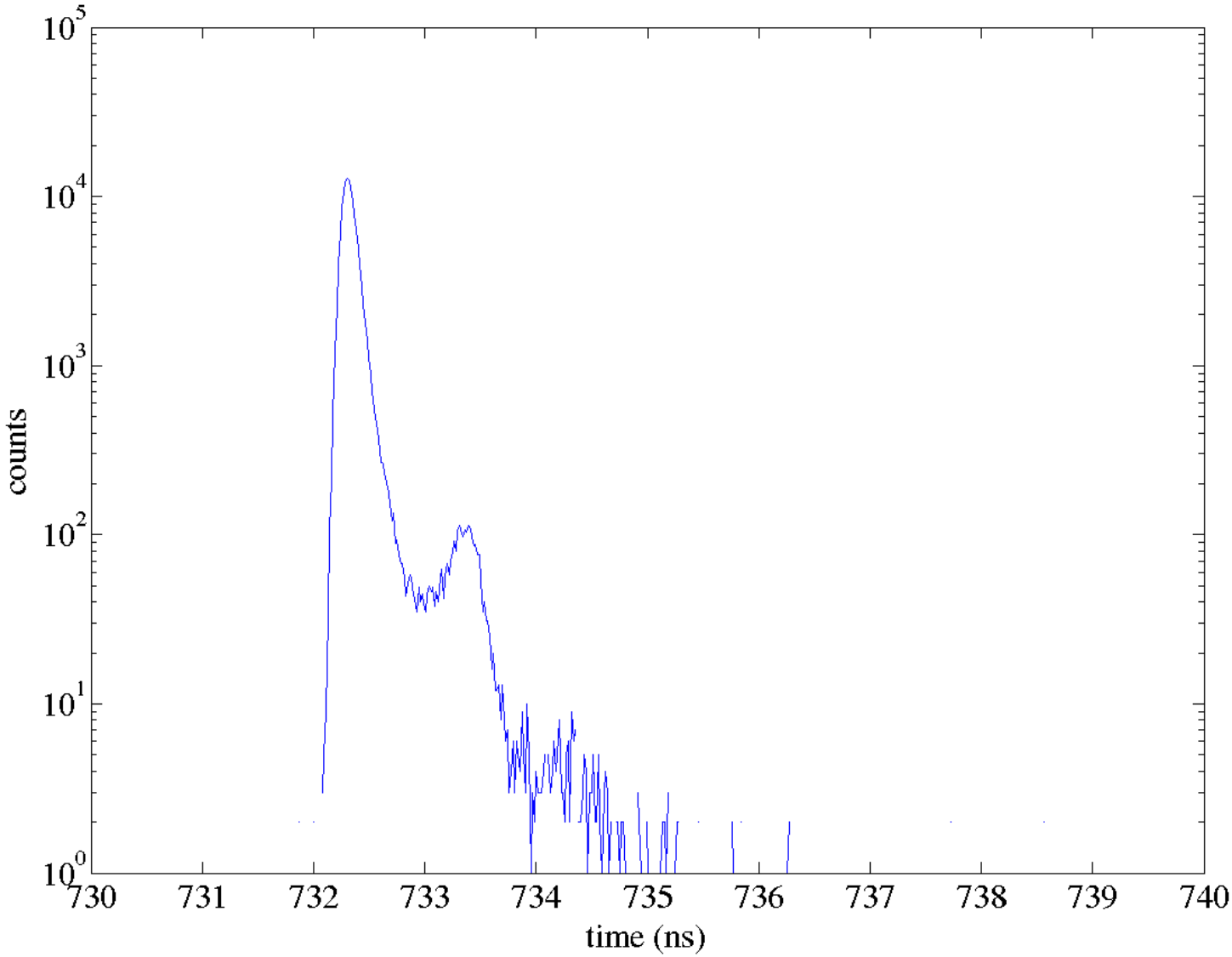
Single Bunch



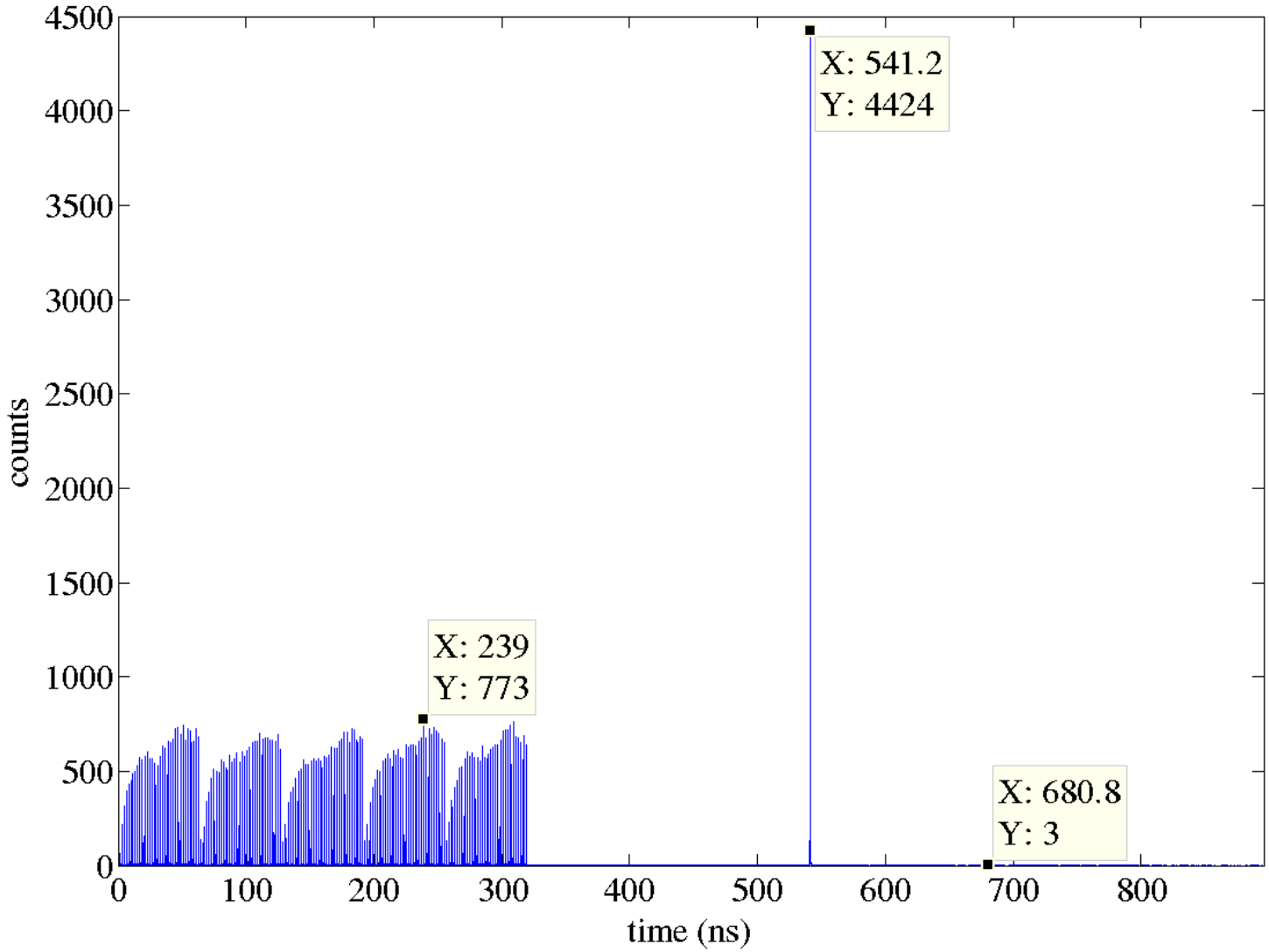
Single Bunch



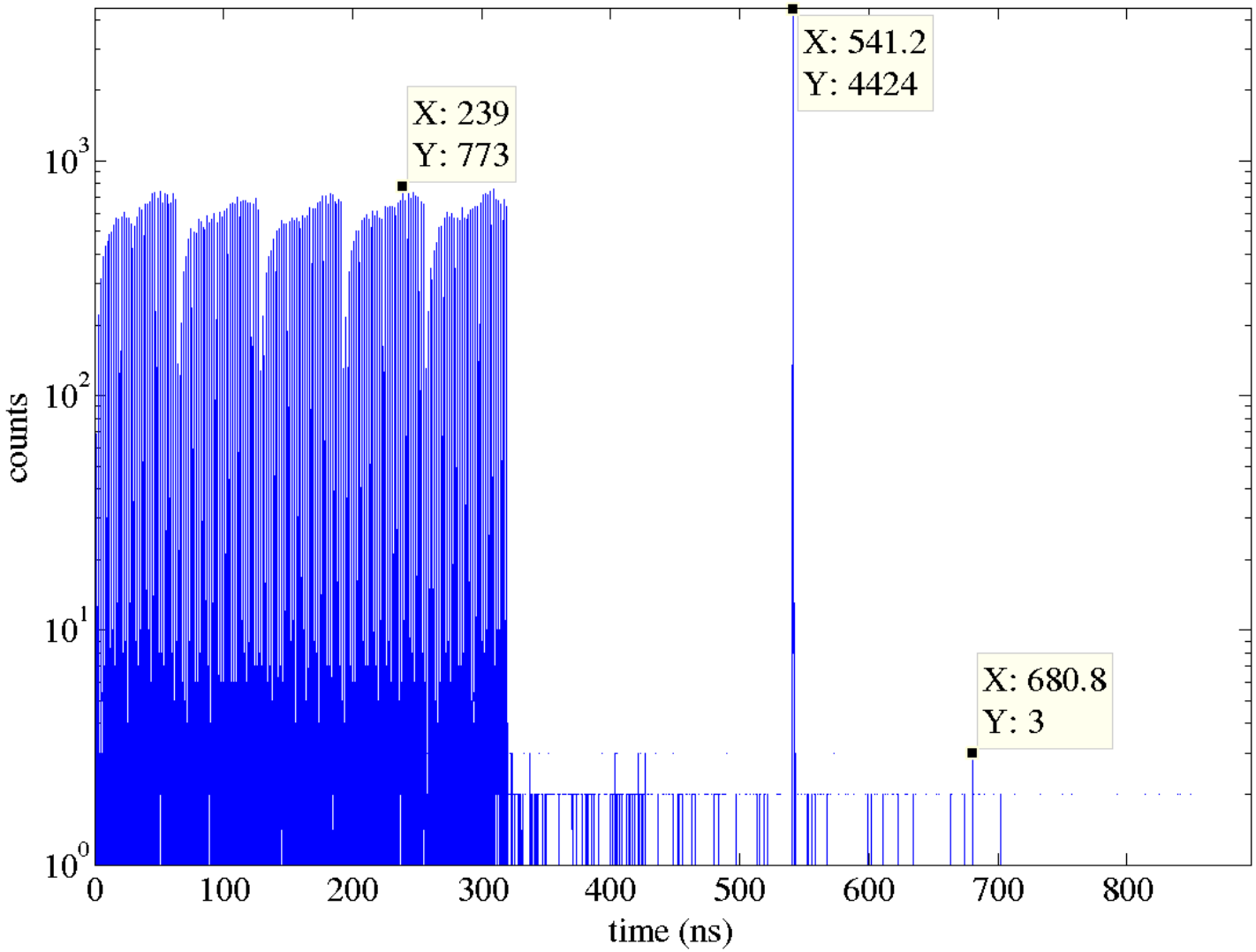
Single Bunch



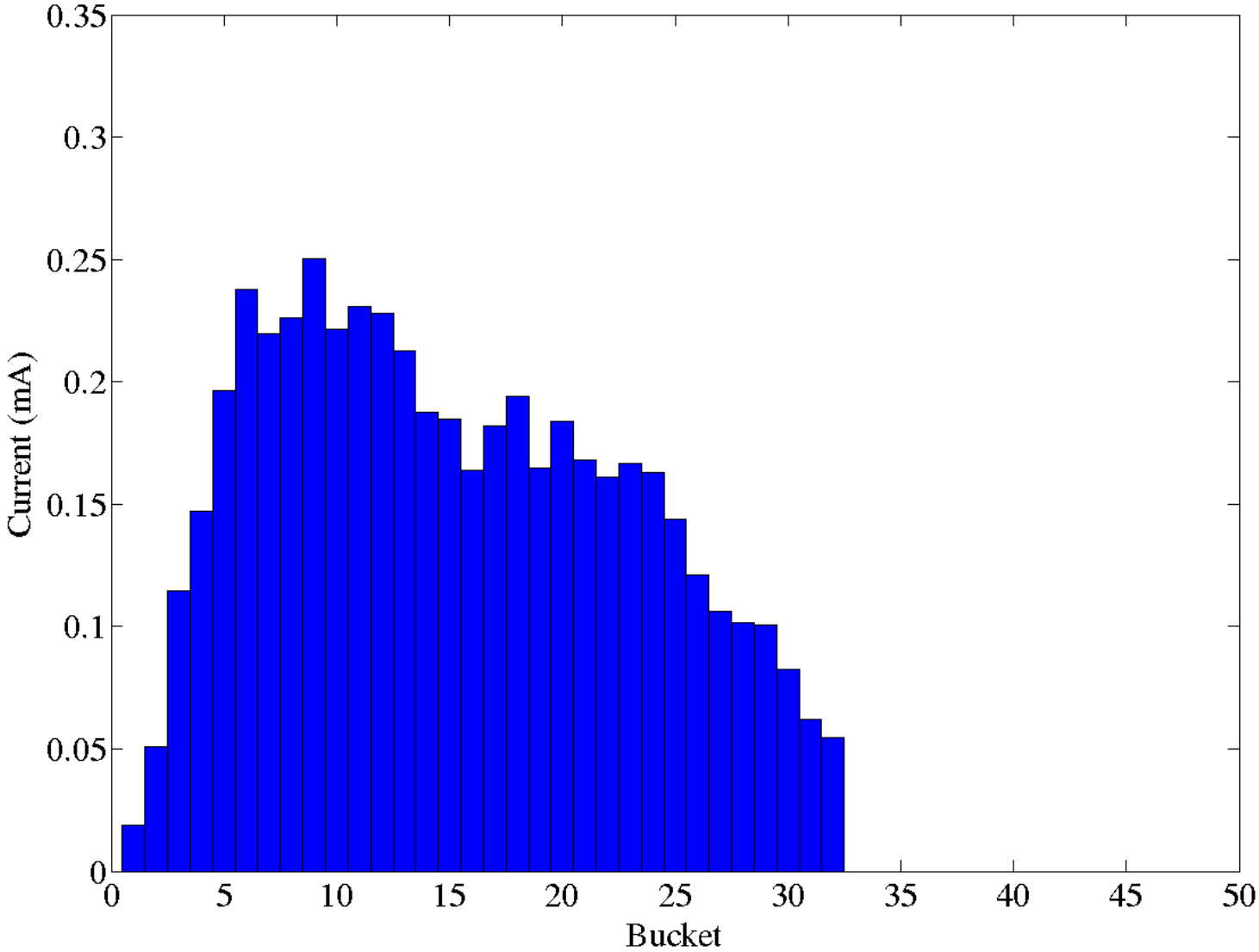
Hybrid Filling Pattern



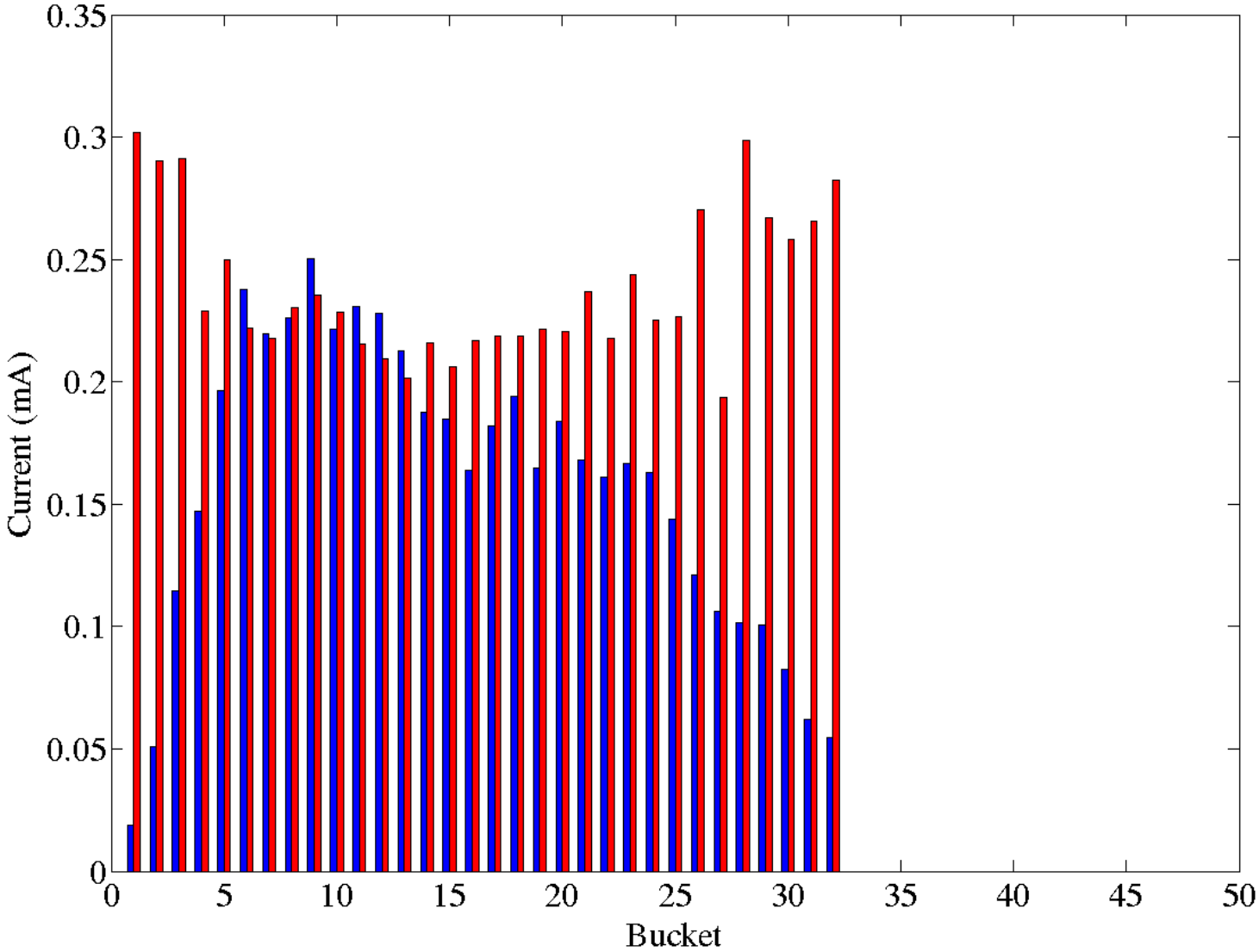
Hybrid Filling Pattern



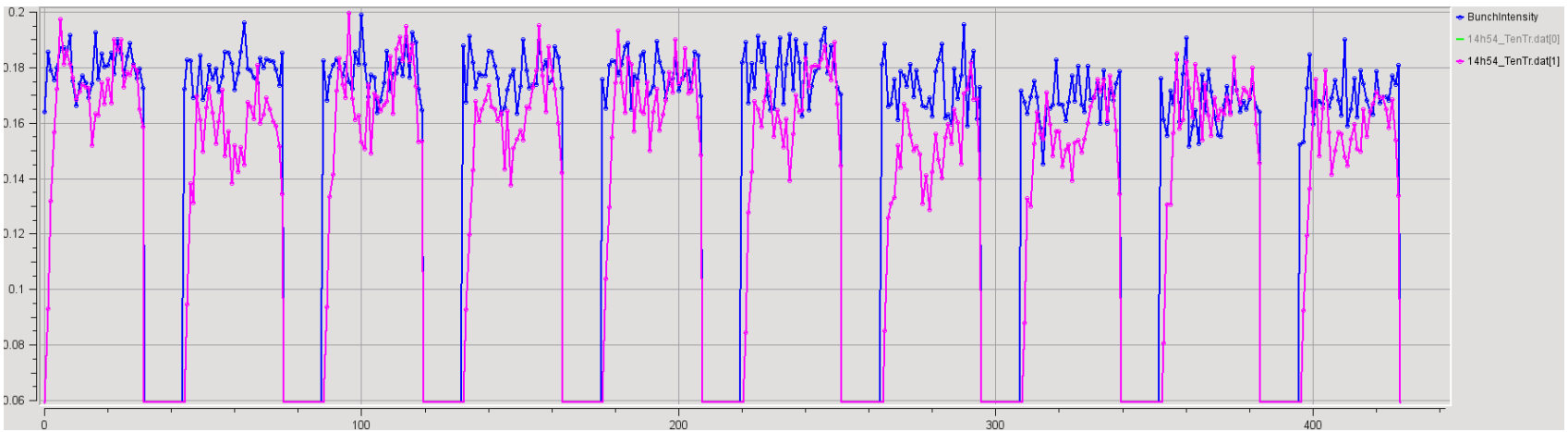
Application: Top-Up selective refilling



Application: Top-Up selective refilling

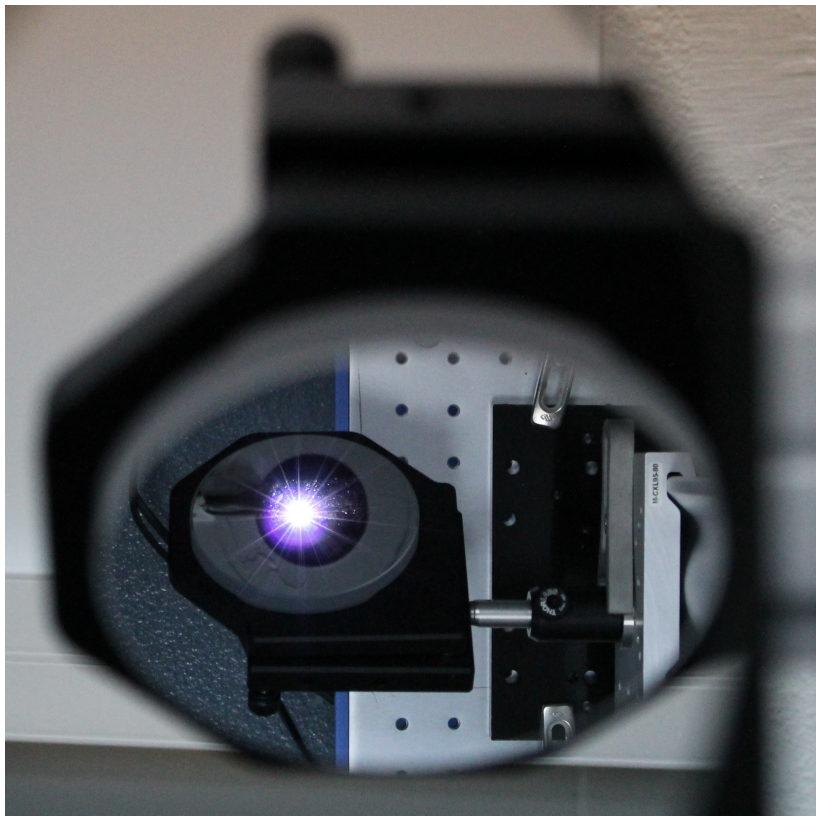


Application: Top-Up selective refilling



Conclusions

The Time Correlated Single Photon Counting is now fully operative at ALBA.



Many thanks to Dr. U. Iriso, S. Blanch, A. Camps and all the ALBA staff for the patience and the help!

This project is funded by the European Union under contract PITN-GA-2011-289485